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Fukuchi et al.

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(54) **HOT PRESS MOLDING METHOD AND HOT PRESS MOLDING DIE**

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USPC 72/342.2
See application file for complete search history.

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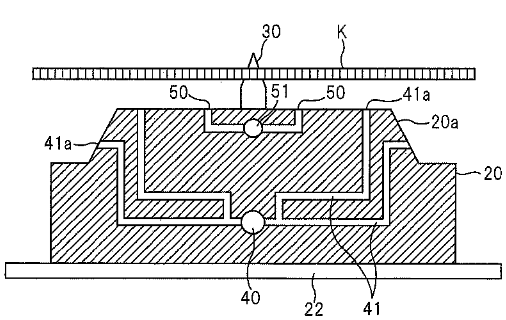
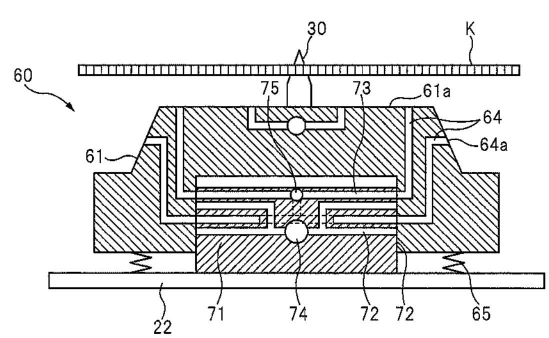
(57) **ABSTRACT**

The present invention provides a hot press molding method for molding a heated metallic plate (K) using a molding die (**20**, **60**) comprising an upper die (**21**) and a lower die (**20**). According to the method, the heated metallic plate is arranged between the upper die and the lower die, the upper die and the lower die are brought together, and the metallic plate held between the dies is pressed. After the metallic plate is pressed, a refrigerant in the form of a liquid or mist is supplied via a plurality of supply holes provided to the lower die to a surface of the metallic plate held between the dies, and once the refrigerant has finished being supplied, a gas is sprayed onto the surface of the metallic plate via the plurality of supply holes. It is thereby possible to remove, with maximum speed, liquid refrigerant adhering to the metallic plate when the supply of liquid refrigerant is stopped.

14 Claims, 6 Drawing Sheets





(51) **Int. Cl.**

B21D 24/16	(2006.01)
B21D 28/26	(2006.01)
B21D 37/16	(2006.01)
B21D 43/00	(2006.01)
C21D 1/673	(2006.01)

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Fig.1

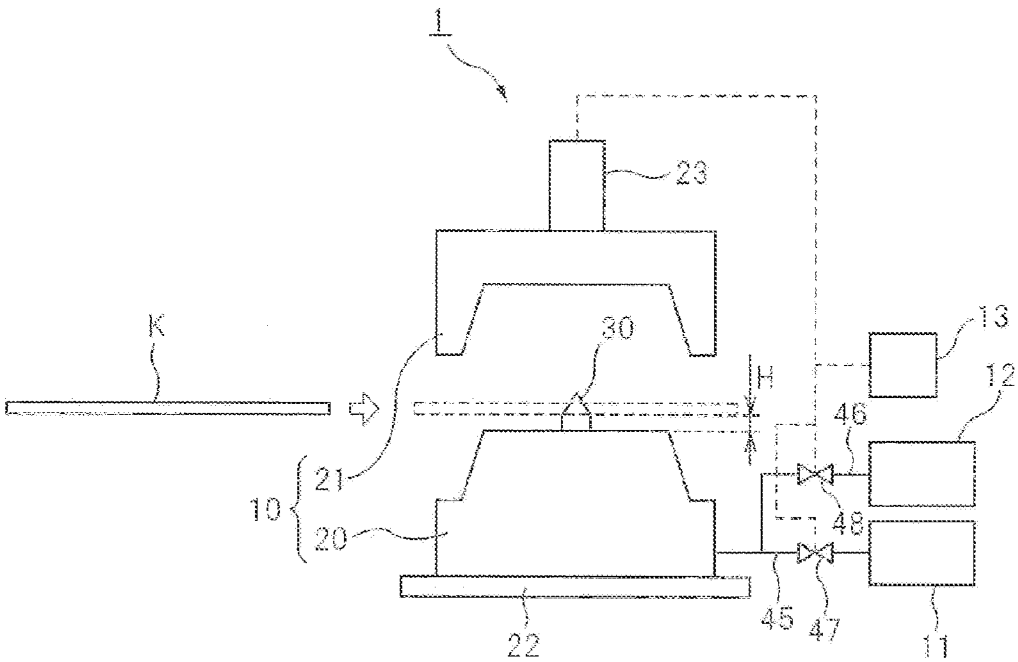


Fig.2

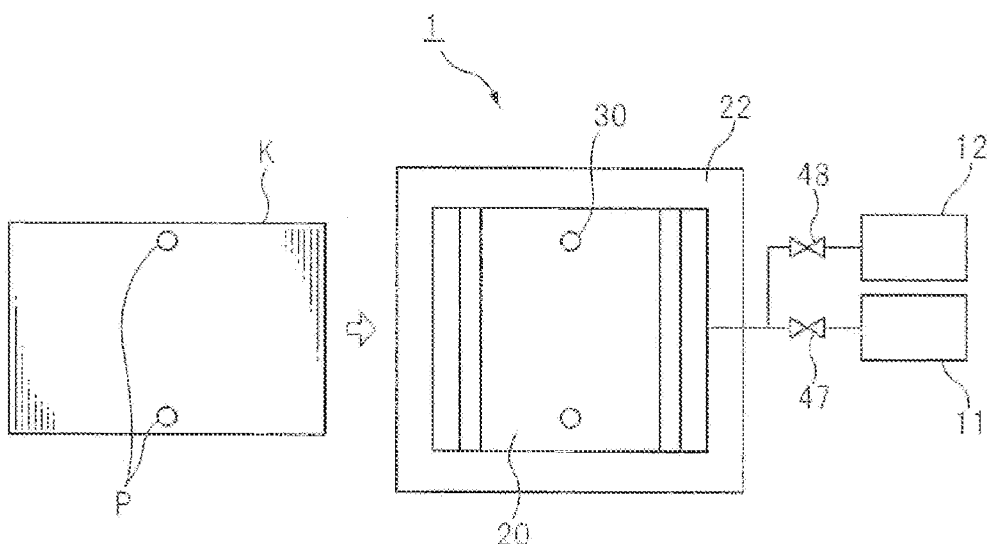
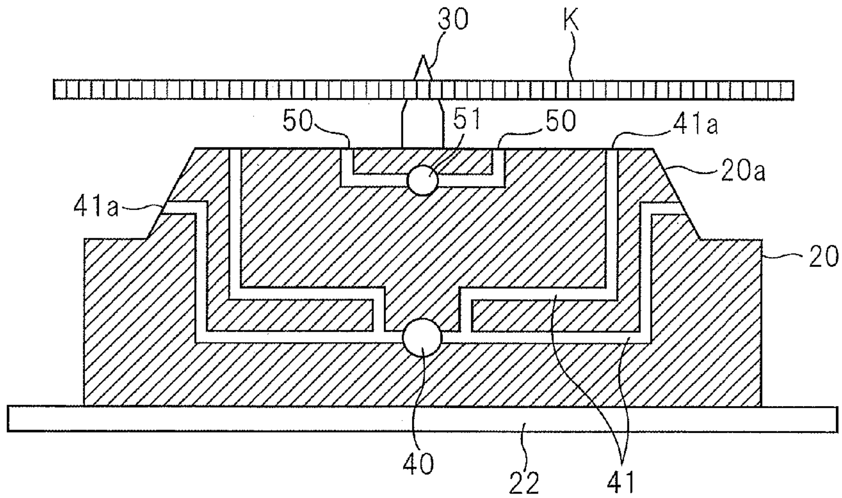


Fig.3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K
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51
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41a
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41a
20
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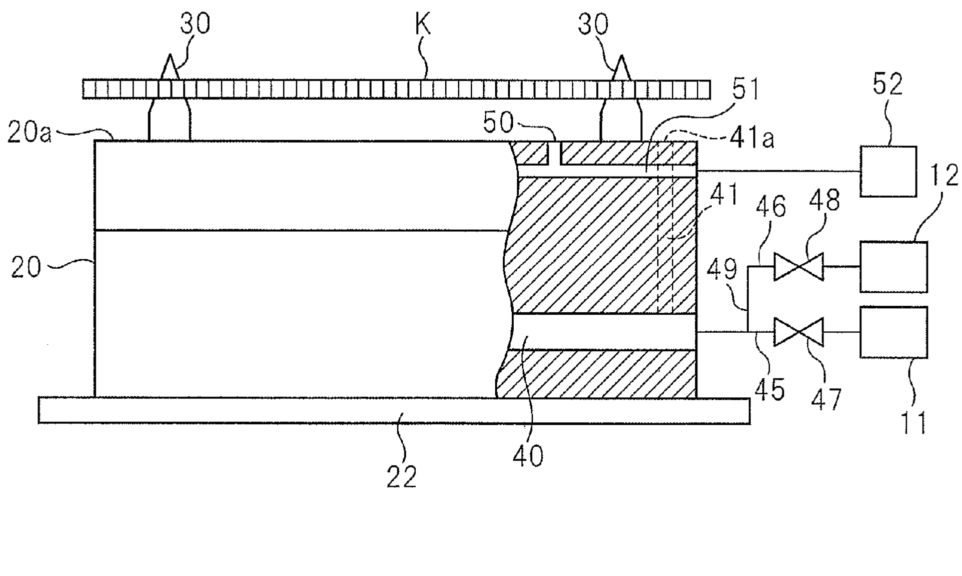
22
41

Fig.4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41
46
48
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49
45
47
11
40
22

Fig.5

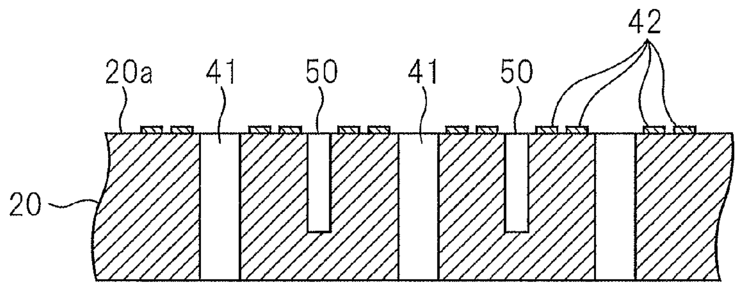


Fig.6

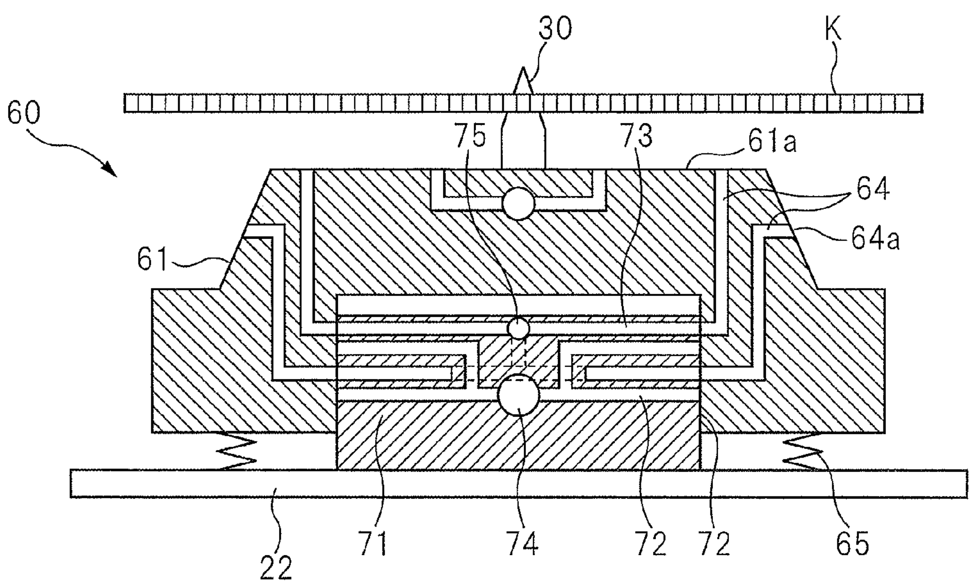
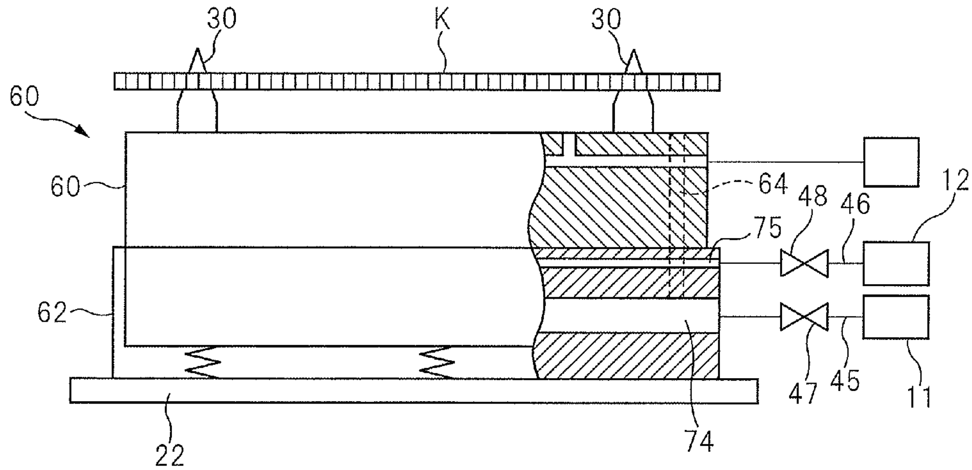


Fig.7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K
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60
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62
47
45
11
22
74

Fig.8

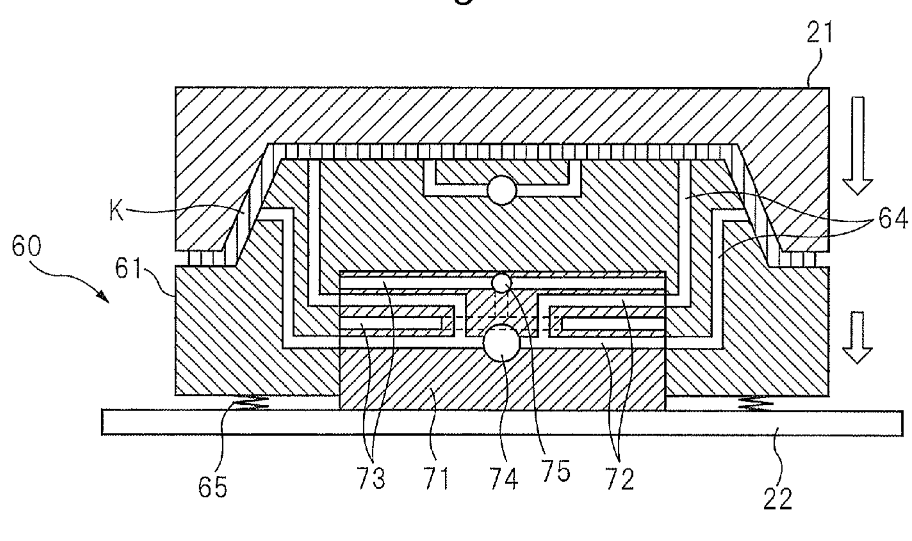

21
K
64
60
61
65
73
71
74
75
72
22

Fig.9

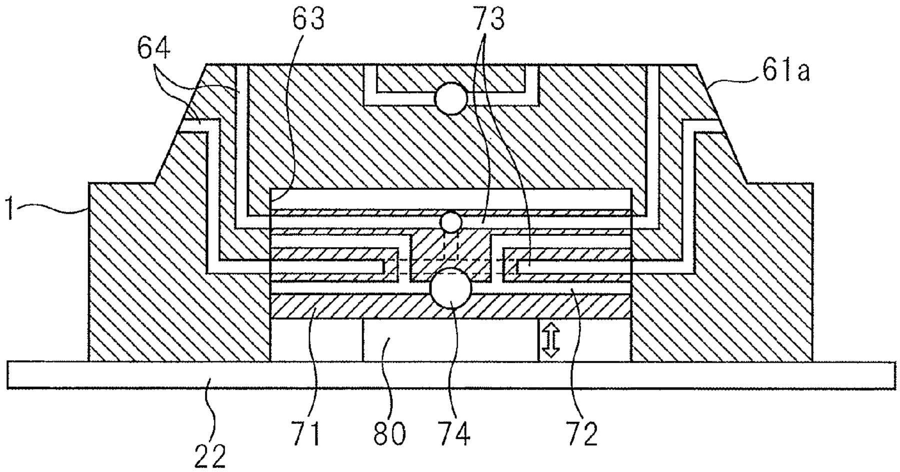


Fig.10

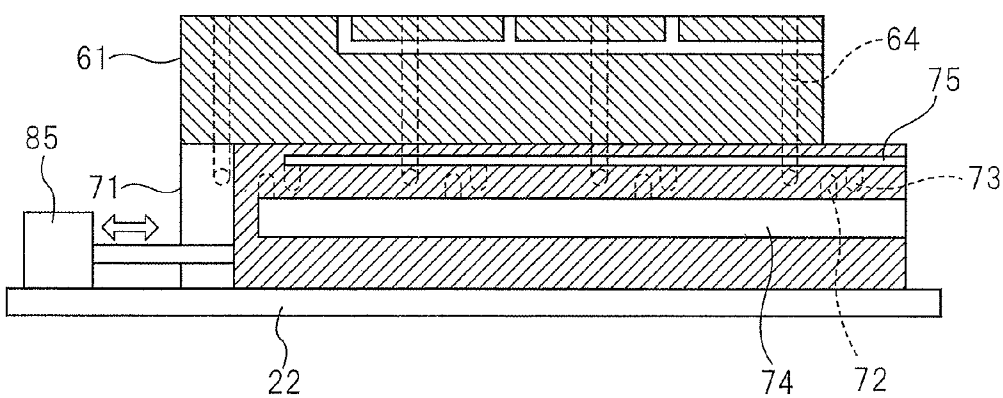
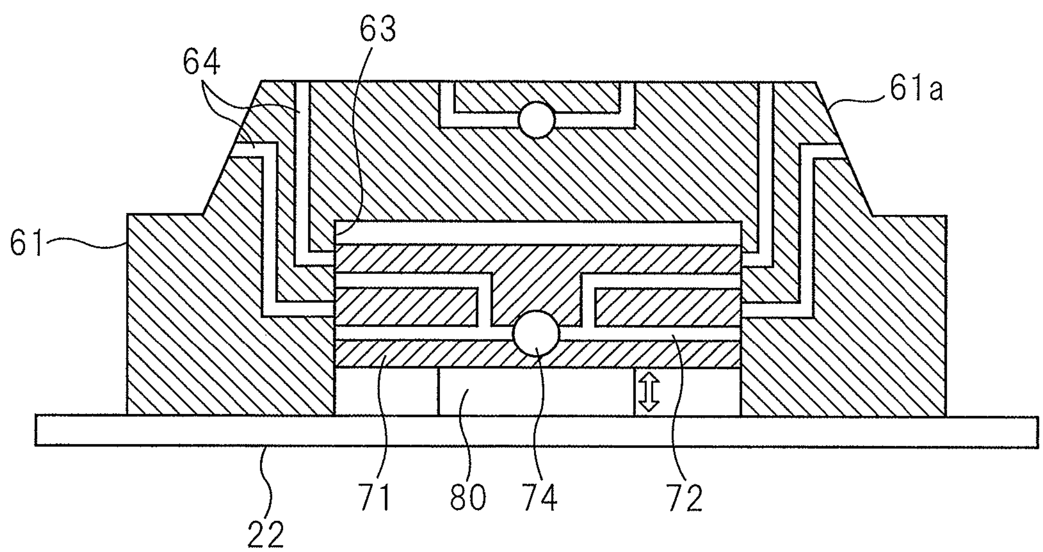


Fig.11



HOT PRESS MOLDING METHOD AND HOT PRESS MOLDING DIE

TECHNICAL FIELD

The present invention relates to a hot press forming method and a hot press forming die of a metal sheet.

BACKGROUND ART

In recent years, as means for shaping steel sheet for auto parts using high strength steel sheet, hot press forming has increasingly been employed. Hot press forming shapes the steel sheet at a high temperature to thereby form it at a stage of a low deformation resistance and then rapidly cools it to quench harden it. With hot press forming, it is possible to press-form parts which are high in strength and are high in shape precision without causing deformation or other shaping problems after shaping.

Specifically, with the hot press forming method, first, steel sheet which has been heated in advance by a heating furnace to a predetermined temperature is supplied to a press die. After this, in a state placed on the bottom die (die) or in a state lifted from the bottom die by lifters or other fixtures built in the bottom die, a top die (punch) is descended to the bottom die limit. Next, the steel sheet is cooled for a certain time (usually 10 seconds to 15 seconds) to cool the steel sheet to a desired temperature. Further, after the cooling finishes, the shaped steel sheet is taken out from the die, then a new steel sheet which has been heated to a predetermined temperature is supplied to the press die. The steel sheet is quenched, tempered, and otherwise heat treated in the cooling process. Therefore, in hot press forming, freely controlling the cooling rate from the viewpoint of the heat treatment characteristics of the steel sheet, obtaining a uniform cooling rate at the steel sheet as a whole from the viewpoint of stability of quality, and shortening the time required for the cooling process after shaping the steel sheet from the viewpoint of productivity, are important.

As means for shortening the cooling time of the shaped steel sheet, it has been proposed to not make the die directly rob heat from the steel sheet, but to feed another medium, for example, water, to the surface of the steel sheet (for example, PLT 1). In particular, in the hot press forming apparatus which is described in PLT 1, the inside surface of the die is provided with a plurality of independent projections of certain heights and channels for water which are communicated with plurality of locations at the inside surface of the die are provided inside the die. Due to this, it is possible to run coolant through the channels inside of the die in the clearances, which are formed by the projections, between the inside surface of the die and the steel sheet. For this reason, it is possible to cool the metal sheet in a short time and raise the productivity of the hot press forming operation. Further, this quenching by rapid cooling enables the steel sheet to be raised in hardness and the strength of the shaped part to be greatly improved.

Further, as means for shortening the time which is required for the cooling process after shaping the steel sheet, it has been proposed to arrange a storage container storing a coolant as close to the steel sheet as possible (for example, PLT 2). In particular, the die which is described in PLT 2 is provided with a storage container which stores a coolant, a plurality of feed holes which feed coolant which is stored in the storage container to the steel sheet, and a coolant feed control device which is provided between the storage container and the feed holes. By having a storage container of coolant arranged inside the die in this way, it is possible to shorten the distance between the storage location of the coolant and feed locations of the coolant. Due to this, it becomes possible to immediately feed coolant to the steel sheet after the control device is sent a coolant feed instruction, and therefore the time from press forming the steel sheet to the end of the cooling process can be shortened.

CITATIONS LIST

Patent Literature

PLT 1: Japanese Patent Publication No. 2005-169394 A
PLT 2: Japanese Patent Publication No. 2007-136535 A

SUMMARY OF INVENTION

Technical Problem

In this regard, in general the heat conduction rate of a liquid is higher than the heat conduction rate of a gas, and therefore when using a liquid state coolant as a coolant for cooling the metal sheet after being pressed, the metal sheet can be cooled quickly compared with the case of using a gas state coolant. From this viewpoint, in both the above PLTs 1 and 2, as the coolant, a liquid, in particular water, is used.

In this regard, when using a liquid state coolant for cooling the metal sheet, even after stopping the feed of the liquid state coolant, the liquid state coolant remains on the surface of the metal sheet. This liquid state coolant does not remain on the entire surface of the metal sheet uniformly, but locally deposits on the surface of the metal sheet. In this case, regions where the liquid state coolant remains are rapidly cooled, while regions where liquid state coolant does not remain are not cooled that much. For this reason, the metal sheet is unevenly cooled and as a result the metal sheet becomes uneven in strength. Further, when using a liquid state coolant comprised of water or another highly corrosive liquid (liquid which easily causes a metal etc. to corrode), if the liquid state coolant remains on the surface of the metal sheet, corrosion of the metal sheet will be invited.

For this reason, to suppress uneven strength or corrosion of a metal sheet, it is considered necessary to remove the liquid state coolant which has deposited on the surface of the metal sheet as quickly as possible after pressing.

Therefore, in consideration of the above problem, an object of the present invention is to provide a hot press forming method and a hot press forming die which can remove the liquid state coolant which has deposited on the surface of the metal sheet as fast as possible when stopping the feed of the liquid state coolant.

Solution to Problem

The inventors studied various hot press forming methods and various hot press forming dies relating to the removal of the liquid state coolant which deposited on the surface of a metal sheet when stopping the feed of the liquid state coolant.

As a result, they discovered that by providing the hot press forming die with a plurality of feed holes able to feed fluid to the metal sheet and by not only feeding liquid state coolant through these feed holes to the surface of the metal sheet, but also blowing a gas on the surface of the metal sheet, it is possible to remove the liquid state coolant which has deposited on the surface of the metal sheet member as fast as possible when stopping the feed of the liquid state coolant.

The present invention was made based on the above findings and has as its gist the following:

(1) A hot press forming method which shapes a heated metal sheet using a forming die which is comprised of a first die and a second die, comprising steps of: arranging the heated metal sheet between the first die and the second die; making the first die and the second die approach to press the metal sheet which is clamped between the two dies; after pressing the metal sheet, feeding liquid state or mist state coolant to the surface of the metal sheet which is clamped between the two dies through a plurality of feed holes which are provided at least at one of the first die and the second die; and, after the coolant finishes being fed, blowing a gas through the plurality of feed holes to the surface of the metal sheet.

(2) The hot press forming method as set forth in (1) wherein the first die and second die are separated before feeding the gas to the surface of the metal sheet.

(3) The hot press forming method as set forth in (1) or (2) wherein a fluid switching means for switching the coolant and the gas which are fed to the plurality of feed holes is provided inside at least one of the first die and second die.

(4) The hot press forming method as set forth in (3) wherein at least one of the first die and the second die has an outside die at which the feed holes are provided and an inside die which is arranged slidably inside the outside die; the outside die is provided inside it with outside pipes which are arranged between a sliding surface between the outside die and the inside die, and the feed holes; the inside die is provided inside it with first inside pipes which are arranged between the sliding surface and a connecting part which is connected to a coolant feed source and with second inside pipes which are arranged between the sliding surface and a connecting part which is connected to a gas feed source; and the fluid switching means makes the outside die and the inside die slide relative to each other to connect the outside pipes with the first inside pipes or second inside pipes and thereby switch between the coolant and the gas which is fed to the plurality of feed holes.

(5) The hot press forming method as set forth in any one of the above (1) to (4) wherein the coolant is either water or anti-rust oil.

(6) A hot press forming die which presses and cools a heated metal sheet, comprising: an outside die provided with feed holes which feed fluid to the metal sheet; and an inside die which is arranged slidably inside the outside die, wherein the outside die is provided inside it with outside pipes which are arranged between a sliding surface between the outside die and the inside die and the feed holes; the inside die is provided inside it with first inside pipes which are arranged between the sliding surface and a connecting part which is connected to a coolant feed source and with second inside pipes which are arranged between the sliding surface and a connecting part which is connected to a gas feed source; and the outside pipes, first inside pipes, and second inside pipes are formed so that the outside pipes can be switched between at least a state connected to the first inside pipes and a state connected to the second inside pipes by making the outside die and the inside die move relative to each other.

(7) The hot press forming die as set forth in the above (6) wherein the outside pipes, first inside pipes, and second inside pipes are formed so that the outside pipes to be switched between a state connected to the first inside pipes, a state connected to the second inside pipes, and a state not connected to the two inside pipes, by making the outside die and the inside die move relative to each other.

(8) The hot press forming die as set forth in the above (6) or (7) wherein the pipeline lengths of the outside pipes are equal.

(9) The hot press forming die as set forth in any one of the above (6) to (8) wherein the die which is comprised of the inside die and the outside die is used as at least one of a top die and bottom die for press forming.

(10) The hot press forming die as set forth in any one of the above (6) to (9) wherein the coolant is any of water, an anti-rust oil, and mists of the same.

Advantageous Effects of Invention

According to the present invention, it is possible to quickly remove the liquid state coolant which was deposited on the surface of a metal sheet at the time of stopping the feed of the liquid state coolant and, as a result, it is possible to suppress uneven strength of the shaped metal sheet and corrosion of the metal sheet.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a side view which schematically shows the configuration of a hot press forming apparatus.

FIG. **2** is a plan view which schematically shows the configuration of the hot press forming apparatus.

FIG. **3** is a longitudinal cross-sectional view which schematically shows the configuration of a bottom die.

FIG. **4** is a lateral cross-sectional view which schematically shows the configuration of the bottom die.

FIG. **5** is a longitudinal cross-sectional view which shows the configuration near a forming surface of the bottom die.

FIG. **6** is a longitudinal cross-sectional view which schematically shows the configuration of the bottom die which is used in a hot press forming die of a second embodiment.

FIG. **7** is a lateral cross-sectional view which schematically shows the configuration of the bottom die which is used in a hot press forming die of a second embodiment.

FIG. **8** is a view for explaining the state where the top die is pushed down to a bottom die limit.

FIG. **9** is a longitudinal cross-sectional view which schematically shows the configuration of the bottom die according to a modification of the second embodiment.

FIG. **10** is a lateral cross-sectional view which schematically shows the configuration of a bottom die according to a modification of the second embodiment.

FIG. **11** is a longitudinal cross-sectional view which schematically shows the configuration of a bottom die according to a modification of the second embodiment.

DESCRIPTION OF EMBODIMENTS

Below, referring to the figures, embodiments of the present invention will be explained in detail. Note that, in the following explanation, similar components are assigned the same reference numerals.

FIG. **1** is a side view which schematically shows the configuration of a hot press forming apparatus **1** according to a first embodiment of the present invention. FIG. **2** is a plan view which schematically shows the configuration of the hot press forming apparatus **1**.

As will be understood from FIG. **1** and FIG. **2**, the hot press forming apparatus **1** comprises a hot press forming die **10** for shaping a steel sheet K, a coolant feed source **11** which feeds coolant (in the present embodiment, water) to the hot press forming die **10**, a gas feed source **12** which feeds gas (for example, compressed air) used for being blown to the hot press forming die **10**, and a control unit **13** which controls the hot press forming apparatus **1**.

The hot press forming die **10** has a bottom die **20** which is disposed in a lower side and a top die **21** which is disposed in a upper side. The bottom die **20** is arranged on the base **22**. The top die **21** is arranged vertically above the bottom die **20** and facing the bottom die **20** and is configured to be able to be lifted by a lift mechanism **23** in the vertical direction. The lift mechanism **23** performs a lift operation based on a control signal from the control unit **13**.

The bottom die **20** is provided with positioning pins **30** for positioning with prepierced holes P which are preliminarily provided in the steel sheet K. The positioning pins **30** are arranged so as to pass through the inside of the bottom die **20** and stick out vertically upward from the top surface of the bottom die **20**.

The top ends of the positioning pins **30** are formed into substantially conical shapes. For this reason, by fitting the top ends of the substantially conical shapes in the prepierced holes P of the steel sheet K, as shown in FIG. **1** by the broken line, the steel sheet K is supported and positioned. In particular, since the top ends of the positioning pins **30** are substantially conical, by suitably setting the sizes of the prepierced holes P of the steel sheet K, the steel sheet K can be supported in a state with a clearance H of a predetermined distance provided from the bottom die **20**.

Further, the positioning pins **30** are slidable with respect to the bottom die **20**. Further, they are supported at the top surface of the base **22** through not shown biasing means (for example, springs). For this reason, if the top die **21** descends and the positioning pins **30** are pushed down, the steel sheet K is pushed down together with the positioning pins **30**.

FIG. **3** is a cross-sectional view when viewing the bottom die **20** from the front direction, while FIG. **4** is a cross-sectional view when viewing the bottom die **20** from the side direction. As shown in FIG. **3** and FIG. **4**, the bottom die **20** has a forming surface **20***a* which contacts the steel sheet K at the time of pressing. Inside of the bottom die **20**, a header **40** which is connected to the coolant feed source **11** and gas feed source **12**, and a plurality of pipes **41** which run through the inside of the bottom die **20** between the header **40** and the forming surface **20***a*, are provided. In the thus configured bottom die **20**, the fluid which is fed from the coolant feed source **11** and gas feed source **12** is fed through the header **40** and pipes **41** to the surface of the steel sheet K. Therefore, the ends of the pipes **41** at the forming surface **20***a* sides act as feed holes **41***a* which feed fluid to the surface of the steel sheet K. Note that, in the example which is shown in FIG. **3**, to facilitate understanding of the drawing, the feed holes **41***a* are provided at only the left and right sides of the bottom die **20** and are not provided at the center, but in actuality they are preferably arranged evenly over the entire forming surface **20***a* including the center part.

Further, at the forming surface **20***a* of the bottom die **20**, as shown in FIG. **5**, a plurality of constant height independent projections **42** are formed over the entire surface of the region which faces the steel sheet K. Conversely speaking, the forming surface **20***a* of the bottom die **20** is formed with recesses which are formed between the projections **42** over the entire surface of the region which faces the steel sheet K. Due to this, when the top die **21** pushes down the bottom surface of the steel sheet K to a position which contacts the forming surface **20***a* of the bottom die **20**, a clearance is formed between the forming surface **20***a* and the bottom surface of the steel sheet K between the plurality of projections **42**. For this reason, by feeding coolant to the clearance from the pipes **41**, the steel sheet K can be rapidly cooled.

The header **40**, as shown in FIG. **4**, is connected through a coolant feed pipe **45** to the coolant feed source **11** and is connected through a gas feed pipe **46** to the gas feed source **12**. The coolant feed pipe **45** is provided with a valve **47**, while the gas feed pipe **46** is provided with a valve **48**. The valve **47** and valve **48** are connected to the control unit **13**. The control unit **13** is used to operate the valve **47** and the valve **48** to open and close. Therefore, by operating the valve **47** which is provided at the coolant feed pipe **45**, the feed and stopping of the coolant are controlled, while by operating the valve **48** which is provided at the gas feed pipe **46**, the feed and stopping of the gas are controlled.

Note that, in the example which is shown in FIGS. **1**, **2**, and **4**, the coolant feed pipe **45** and gas feed pipe **46** are provided with valves **47** and **48**. However, the merged part **49** of the coolant feed pipe **45** and the gas feed pipe **46** may be provided with a three-way valve to control the fluid which is fed to the header **40**.

Further, in the present embodiment, the forming surface **20***a* of the bottom die **20**, as shown in FIG. **3** and FIG. **4**, is provided with exhaust suction holes **50** which suck in the coolant etc. which is fed though the feed holes **41***a* to the surface of the steel sheet K and discharge the coolant from around the surface of the steel sheet K. The exhaust suction holes **50** are connected to a suction pipe **51**, while the suction pipe **51** is connected to for example a vacuum pump or other exhaust mechanism **52**.

Note that, to enable the coolant etc. which is fed from the feed holes **41***a* to be smoothly discharged through the exhaust suction holes **50**, the exhaust suction holes **50** should be atmospheric pressure or less. That is, for example, if opening the end of the suction pipe **51** at the opposite side to the exhaust suction holes **50** to the atmosphere, the extraneous coolant around the surface of the steel sheet K will be discharged outside of the die. For this reason, the exhaust mechanism **52** need not necessarily be provided.

Note that, in the present embodiment, water is used as the coolant which is fed from the coolant feed source **11**, but aside from water, anti-rust oil which has a rust prevention function or another liquid state coolant may also be used. Further, a mist of water or anti-rust oil etc. or other mist-like coolant can be used. Further, in the present embodiment, as the gas which is fed from the gas feed source **12**, compressed air is used, but the invention is not limited to this. For example, so long as a gas which is fed at a pressure of atmospheric pressure or more, nitrogen gas or another gas other than air may be used. In particular, when using nitrogen as the gas which is fed from the gas feed source **12**, the surroundings of the steel sheet K may be a nonoxidizing atmosphere, and therefore rusting of the steel sheet K can be further suppressed.

Next, the method of using the thus configured hot press forming apparatus **1** to form steel sheet K by hot press will be explained next.

First, when starting the press forming of the steel sheet K, the valves **47** and **48** are closed. Due to this, the pipes **41** of the bottom die **20** are not fed with either coolant or gas. In such a state, a steel sheet K which has been heated to a predetermined temperature (for example, 700° C. to 1000° C.) is placed by a conveyor apparatus (not shown) between the bottom die **20** and the top die **21**. Specifically, the steel sheet K is placed on the positioning pins **30** of the bottom die **20** so that the prepierced holes P fit into the positioning pins **30**.

Next, the top die **21** is moved in the vertical direction so as to approach the bottom die **20** to press the steel sheet K which is clamped between the top die **21** and bottom die **20**. When the top die **21** descends to the bottom die limit and the press operation is completed, the valve **47** which is provided at the coolant feed pipe **45** is opened. When the valve **47** is opened, coolant is fed from the coolant feed source **11** through the coolant feed pipe **45**, header **40**, pipes **41**, and feed holes **41***a* to the surface of the steel sheet K. Due to this, the steel sheet K starts to be rapidly cooled.

Further, if the top die **21** is held at the bottom die limit for a certain time and the steel sheet K is cooled to a temperature of for example 200° C. or less, next, the valve **47** which is provided at the coolant feed pipe **45** is closed and the valve **48** which is provided at the gas feed pipe **46** is opened. If the valve **48** is opened, the gas is blown from the gas feed source **12** through the gas feed pipe **46**, header **40**, pipes **41**, and feed holes **41***a* to the surface of the steel sheet K. At this time, if the pressure of the gas which is fed from the feed holes **41***a* is too high, the pressurizing energy becomes high, while conversely if too low, gas is no longer evenly ejected from the feed holes **41***a*, and therefore the pressure is set to 0.1 to 1.0 MPa, preferably 0.3 to 0.7 MPa, more preferably 0.4 to 0.5 MPa. The flow rate is determined by the pressure of the gas and the nozzle shape and is set to 20 to 2000 ml/sec, preferably 300 to 1000 ml/sec, more preferably 400 to 700 ml/sec.

Further, the temperature of the gas which is fed from the feed holes **41***a* is set to 200° C. or less, preferably ordinary temperature. That is, the steel sheet K is cooled by the coolant down to 200° C. or less, whereby it is quenched. For this reason, if blowing 200° C. or more gas, the steel sheet K becomes at a temperature of 200° C. or more, the steel sheet K is annealed, and the hardness falls.

Further, in the present embodiment, along with the closing of the valve **47** or the opening of the valve **48**, the top die **21** is risen to top die limit. If the top die **21** rises in this way, the positioning pins **30** which had been pushed downward by the top die **21** rise and the steel sheet K is separated from the forming surface **20***a* of the bottom die **20**. Due to this, a clearance is formed between the bottom surface of the steel sheet K and the forming surface **20***a* of the bottom die **20**.

Further, if blowing gas to the surface of the steel sheet K and thereby finishing removing the coolant on the surface of the steel sheet K, the shaped steel sheet K is taken off by the conveyor apparatus (not shown) from the positioning pins **30** and is unloaded from the hot press forming apparatus **1**. Further, a heated new steel sheet K is placed by a conveyor apparatus (not shown) on the positioning pins **30** of the hot press forming apparatus **1** and this series of steps in the hot press forming operation is repeated.

Next, the advantageous effects of the hot press forming die and hot press forming method according to the above embodiment will be explained.

According to the above embodiment, in the state with a steel sheet K placed on the same hot press forming die **10**, the surface of the steel sheet K was fed with coolant from the coolant feed source **11** and blown with gas from the gas feed source **12**. For this reason, it is possible to blow gas to the surface of the steel sheet K immediately after stopping feeding of the coolant to the surface of the steel sheet K. For this reason, it is possible to quickly remove the coolant which has deposited on the surface of the steel sheet K.

Note that, the time which is taken for removing the coolant which is deposited on the surface of the steel sheet K depends on the temperature and sheet thickness of the shaped steel sheet K (that is, the heat capacity of the steel sheet K). For example, if making the pressure of the gas which is fed from the feed holes **41***a* 0.4 MPa, making the flow rate 60 to 70 ml/sec, and making the temperature ordinary temperature, if the temperature of a sheet thickness 1.4 mm steel sheet K right after pressing is about 150° C., it is possible to remove the coolant which deposited on the steel sheet K in about 3 seconds from the start of blowing of the gas. Further, in the case of sheet thickness 1.2 mm steel sheet K, it is possible to remove the coolant which deposited on the steel sheet K in about 7 seconds from the start of blowing of the gas.

In this way, it is possible to quickly remove the coolant which deposited on the surface of the steel sheet K, and therefore it is possible to suppress uneven cooling of the steel sheet K due to coolant remaining on the surface of the steel sheet K in an uneven manner. Accordingly, it is possible to keep the strength of the steel sheet K from becoming uneven. Further, even when using water as a coolant, it is possible to keep rust from forming due to the coolant which remains on the surface of the steel sheet K.

Further, after being pressed by the hot press forming die **10**, the surface of the steel sheet K is sprayed with gas whereby the scale which formed on the surface of the steel sheet K due to the pressing etc. can be removed. In particular, if the coolant is removed from the surface of the steel sheet K and the surface of the steel sheet K is dried, the scale easily peels off, and therefore in the present embodiment, the scale can be removed more efficiently.

Further, in the above embodiment, the clearance H is formed when blowing gas on the surface of the steel sheet K. By such a clearance H being formed, the gas which is fed from the gas feed source **12** through the feed holes **41***a* is easily exhausted and the flow rate of the gas which passes over the surface of the steel sheet K can be raised. Due to this, the coolant which deposited on the surface of the steel sheet K can be efficiently removed. Note that, if the clearance H is too small, it becomes difficult to draw in the surrounding gas while conversely if too large, the blown gas will disperse and the effect of blowing it will fall, and therefore the clearance is 1 mm to 100 mm or so, preferably 5 to 20 mm, more preferably 8 to 15 mm.

Next, referring to FIG. **6** and FIG. **7**, a second embodiment of the present invention will be explained. The configuration of the hot press forming apparatus of the second embodiment is basically similar to the configuration of the hot press forming apparatus of the first embodiment. However, in the hot press forming apparatus of the second embodiment, the configuration of the bottom die **60** differs from the configuration of the bottom die **20** of the first embodiment.

FIG. **6** is a longitudinal cross-sectional view similar to FIG. **3** which schematically shows a bottom die **60** which is used in the hot press forming apparatus of the second embodiment, while FIG. **7** is a lateral cross-sectional view similar to FIG. **4** which schematically shows the bottom die **60**. As shown in FIG. **6** and FIG. **7**, the bottom die **60** has an outside die **61** which has a forming surface **61***a* which contacts the steel sheet K and an inside die **71** which is provided slidably with respect to the outside die **61** at the inside of the outside die **61**. In the present embodiment, the inside die **71** has a rectangular cross-sectional shape. Note that, in FIG. **7**, for convenience of illustration, the outside die **61** is drawn slightly shorter than the inside die **71** in the lateral direction of FIG. **7**.

The outside die **61** is provided with a plurality of outside pipes **64** which run from the forming surface **61***a* which contacts the steel sheet K to the sliding surface **63** between the outside die **61** and inside die **71**, through the inside of the outside die **61**. The ends of the outside pipes **64** at the forming surface **61***a* sides, in the same way as the feed holes **41***a* of the first embodiment, act as feed holes **64***a* which feed fluid to the surface of the steel sheet K. Therefore, the outside pipes **64** can be said to be arranged between the feed holes **64***a* and the sliding surface **63**. The forming surface **61***a*, like the forming surface **20***a* of the first embodiment, is formed with a plurality of projections.

Further, the outside die **61** is supported through elastic members **65** on the base **22**. As the elastic members **65**, for example, springs of predetermined stroke lengths are used. For this reason, if the top die **21** descends and pushes the outside die **61**, the outside die **61** is guided by the sliding surface **63** while being pushed downward. The guide mechanism for sliding the outside die **61** and the inside die **71** may be provided separately from the sliding surface **63**.

Inside of the inside die **71**, a plurality of first inside pipes **72**, a plurality of second inside pipes **73**, a first header **74** which connects the plurality of first inside pipes **72** and coolant feed source **11**, and a second header **75** which connects the plurality of second inside pipes **73** and gas feed source **12** are provided. The first inside pipes **72** are provided in the same number as the outside pipes **64** of the outside die **61** and run from the sliding surface **63** to the first header **74** through the inside of the inside die **71**. The second inside pipes **73** are also provided in the same number as the outside pipes **64** of the outside die **61** and run from the sliding surface **63** to the second header **75** through the inside of the inside die **71**.

The first header **74**, as shown in FIG. **7**, connects through the coolant feed pipe **45** to the coolant feed source **11** and therefore acts as a connecting part which is connected to the coolant feed source **11**. On the other hand, the second header **75** connects through the gas feed pipe **46** to the gas feed source **12** and therefore acts as a connecting part which is connected to the gas feed source **12**. The coolant feed pipe **45** is provided with the valve **47**, while the gas feed pipe **46** is provided with the valve **48**. The valve **47** and the valve **48**, in the same way as the first embodiment, are connected to the control unit **13**. The control unit **13** is used to operate the valve **47** and the valve **48** to open and close.

The ends of the second inside pipes **73** at the sliding surface **63** sides are arranged so as to be aligned with the ends of the outside pipes **64** at the sliding surface **63** sides in the state where the outside die **61** is not pushed by the top die **21**. Conversely, the ends of the first inside pipes **72** at the sliding surface **63** sides are arranged so as not to be aligned with the ends of the outside pipes **64** at the sliding surface **63** sides in the state where the outside die **61** is not pushed by the top die **21**. Therefore, in the state where the outside die **61** is not pushed by the top die **21**, only the second inside pipes **73**, that is, only the gas feed source **12**, is connected to the outside pipes **64**.

On the other hand, the ends of the first inside pipes **72** at the sliding surface **63** sides are arranged so as to be aligned with the ends of the outside pipes **64** at the sliding surface **63** sides in the state where the outside die **61** is pushed down to the bottom die limit by the top die **21**. Conversely, the ends of the second inside pipes **73** at the sliding surface **63** sides are arranged so as not to be aligned with the ends of the outside pipes **64** at the sliding surface **63** sides in the state where the outside die **61** is pushed down to the bottom die limit by the top die **21**. Therefore, in the state where the outside die **61** is pushed down to the bottom die limit by the top die **21**, only the first inside pipes **72**, that is, only the coolant feed source **11**, is connected to the outside pipes **64**.

In other words, in the present embodiment, the outside die **61** and the inside die **71** slide relative to each other linked with the operation of the top die **21**. Due to this, it is possible to switch between a state where the outside pipes **64** are connected to the first inside pipes **72** and a state where they are connected to the second inside pipes **73**. Note that, when with just the metal surfaces sliding together, it is difficult to seal in the coolant against the pressure of the coolant, the ends of the inside pipes **72** and **73** at the sliding surface **63** sides or the ends of the outside pipes **64** at the sliding surface **63** sides may be provided with rubber rings or other seal members.

Next, the method of using the thus configured hot press forming apparatus to hot press form steel sheet K will be explained.

First, when starting the press forming of the steel sheet K, the valve **48** which is provided at the gas feed pipe **46** is closed and the valve **47** which is provided at the coolant feed pipe **45** is opened. At this time, the outside die **61** is not pushed by the top die **21**, and therefore is lifted by the elastic members **65**. Therefore, the outside pipes **64** are connected, with the second inside pipes **73**. For this reason, even if the valve **47** is opened, the coolant feed source **11** feeds coolant to the first inside pipes **72** at a predetermined pressure and does not feed coolant to the outside pipes **64**. In other words, the coolant which is fed to the first inside pipes **72** is stopped by the sliding surface **63** of the outside die **61** and is filled at a predetermined pressure to the ends of the first inside pipes **72**. On the other hand, the valve **48** is closed, and therefore even if the second inside pipes **73** and the outside pipes **64** are connected, the outside pipes **64** are not fed with gas.

Next, a high temperature steel sheet K is placed by a conveyor apparatus (not shown) on the positioning pins **30** of the bottom die **60**. Next, the top die **21** is moved in the vertical direction so as to approach the bottom die **60** to, for example, as shown in FIG. **8**, make it descend to the bottom die limit. Along with this, the steel sheet K and the outside die **61** of the bottom die **60** are pushed down in the vertical direction and the steel sheet K which is clamped between the top die **21** and the bottom die **60** is pressed.

At this time, the outside die **61** is pushed down to the bottom die limit, whereby the outside pipes **64** of the outside die **61** are disconnected from the second inside pipes **73** of the inside die **71** and are connected to the first inside pipes **72**. Due to this, the coolant which had been filled to the end of the first inside pipes **72** is immediately fed from the outside pipes **64** to the steel sheet K. The steel sheet K starts to be rapidly cooled right after the steel sheet K is pressed.

Further, if the outside die **61** is pushed down to the bottom die limit and thereby the outside pipes **64** and the second inside pipes **73** are disconnected, the valve **48** which is provided at the gas feed pipe **46** is opened. For this reason, the second inside pipes **73** are fed with gas of a predetermined pressure. In other words, the coolant which was fed to the second inside pipes **73** is stopped by the sliding surface **63** of the outside die **61** and is filled at a predetermined pressure to the ends of the second inside pipes **73**.

Further, if the top die **21** is held at bottom die limit for a certain time and the steel sheet K is cooled down to a temperature of for example 200° C. or less, next, the top die

21 is risen to top dead center. If the top die **21** rises to top die limit, the outside die **61** which was pushed down to the bottom die limit is pushed vertically upward by the elastic members **65** which support the outside die **61**. As a result, the outside pipes **64** are disconnected from the first inside pipes **72** and are connected to the second inside pipes **73**. For this reason, the feed of coolant from the outside pipes **64** to the steel sheet K is immediately stopped. In addition, the gas which filled up to the ends of the second inside pipes **73** is immediately fed from the outside pipes **64** to the steel sheet K, and therefore gas starts to be blown to the steel sheet K immediately after stopping the feed of the coolant. At this time, the pressure etc. of the gas which is fed from the feed holes **64***a* are set in the same way as in the first embodiment.

Further, when coolant finishes being removed from the surface of the steel sheet K by blowing gas to the surface of the steel sheet K, the shaped steel sheet K is removed by the conveyor apparatus (not shown) from the positioning pins **30** and is unloaded from the hot press forming apparatus. After this, a heated new steel sheet K is placed by the conveyor apparatus (not shown) on the positioning pins **30** of the hot press forming apparatus and this series of steps of the hot press forming operation are repeated.

Next, the advantageous effects of the hot press forming die and hot press forming method according to the above embodiment will be explained.

According to the present embodiment, the outside pipes **64** and the first inside pipes **72** and second inside pipes **73** are switched to be connected and disconnected by making the outside die **61** and the inside die **71** move relative to each other. Therefore, in the present embodiment, a fluid switching means for switching the fluid which is fed to the plurality of feed holes **64***a* between a coolant and gas can be said to be provided inside of the bottom die. For this reason, the outside pipes **64** and the first inside pipes **72** and second inside pipes **73** are switched to be connected and disconnected at positions close to the feed holes **64***a* which feed fluid (coolant and gas) to the steel sheet K. In other words, control may be performed to feed and stop the fluid at positions close to the forming surface **61***a* of the outside die **61**, that is, positions close to the steel sheet K to which the fluid is to be fed.

For this reason, in the state where the second inside pipes **73** are closed by the sliding surface **63** of the outside die **61**, the gas is fed in advance to the second inside pipes **73** to fill the gas up to the ends of the second inside pipes **73**. After this, the outside die **61** can be pushed up to connect the outside pipes **64** and the second inside pipes **73**. Due to this, the gas which had been filled in the second inside pipes **73** can be quickly blown from the outside pipes **64** to the steel sheet K. Therefore, compared with the first embodiment, it is possible to more quickly blow gas to the surface of the steel sheet K after stopping the feed of coolant to the surface of the steel sheet K.

Similarly, in the state where the first inside pipes **72** are closed by the sliding surface **63** of the outside die **61**, the coolant is fed in advance to the first inside pipes **72** to fill the coolant up to the ends of the first inside pipes **72**. After this, the outside die **61** can be pushed down to the bottom die limit to connect the outside pipes **64** and the first inside pipes **72**. Due to this, coolant which is filled in the first inside pipes **72** can be quickly blown from the outside pipes **64** to the steel sheet K.

Further, for example, at the bottom die **60** which is shown in FIG. **4**, for example, the total pipeline lengths from the valves **47** and **48** to the feed holes **41***a* closest to the valves **47** and **48** (feed holes at right side of FIG. **4**) and the total pipeline lengths to the feed holes **41***a* furthest from the valves **47** and **48** (feed holes at left side of FIG. **4**) greatly differ in length. For this reason, at the positions close to the valves **47** and **48** and the positions far from the valves **47** and **48**, the timings of start of cooling of the steel sheet K and the timings of start of blowing of gas to the steel sheet K differ. As opposed to this, in the hot press forming apparatus of the present embodiment, it is possible to obtain similar effects to the case where valves are provided at the ends of the outside pipes **64** at the sliding surface **63** sides, and therefore it is possible to make the differences in pipeline lengths extremely small compared with the bottom die **60** which is shown in FIG. **4**.

Note that, the outside pipes **64** of the outside die **61** are preferably the same in pipeline lengths. By making the outside pipes **64** the same in pipeline lengths, the times from connection of the outside pipes **64** and the inside pipes **72** and **73** to the start of feed of coolant or gas to the steel sheet K become the same. In this case, it is possible to make the timings of start of cooling and the timings of start of blowing of gas uniform over the surface of the steel sheet K. As a result, the hardness of the steel sheet K after hot press forming can be uniform over the surface.

Note that, the bottom die **60** of the second embodiment can be changed in various ways. Below, modifications of the bottom die **60** are shown.

In the above embodiments, the outside die **61** which is supported by the elastic members **65** is pushed down by the top die **21** whereby the outside die **61** is slid against the inside die **71**. However, if the outside die **61** and the inside die **71** can be slid relative to each other, the inside die **71** can be slid and, further, both the outside die **61** and the inside die **71** can be slid. When making the inside die **71** side, for example as shown in FIG. **9**, the outside die **61** may be directly arranged on the top surface of the base **22** and the inside die **71** may for example be slide by an actuator or other drive mechanism **80** in the up-down direction. In this case, the timing of ending the press operation of the steel sheet K and the timing of start of feed of the coolant can be separately controlled.

Further, when using the drive mechanism **80**, the state where the ends of the outside pipes **64** at the sliding surface **63** sides are connected with the first inside pipes **72**, the state where the ends of the outside pipes **64** at the sliding surface **63** sides are connected with the second inside pipes **73**, and, in addition, the state where the ends of the outside pipes **64** at the sliding surface **63** sides are not connected to either the first inside pipes **72** and second inside pipes **73** (that is, the state where the ends of the outside pipes **64** at the sliding surface **63** sides face the inside wall surface of the inside die **71**) can be switched between. In this case, the valves **47** and **48** no longer need be provided.

Further, in the above embodiments, the dies **61** and **71** were slid in the up-down direction to connect the outside pipes **64** and the inside pipes **72** and **73**. However, the arrangements of the pipes **64**, **72**, and **73** and the directions of relative sliding of the dies **61** and **71** are not limited to those of the present embodiments and can be freely set. For example, when making the dies **61** and **71** slide in the horizontal direction, as shown in FIG. **10**, it is possible to arrange the outside die **61** and the inside die **71** offset in the horizontal direction and shift the inside pipes **72** and **73** from the corresponding outside pipes **64** in the horizontal direction. Further, for example, it is possible to slide the inside die **71** in the horizontal direction by the horizontal movement mechanism **85** so as to connect the first inside pipes **72** and the outside pipes **64** or connect the second inside pipes **73** and the outside pipes. Further, for example, it is possible to make the inside die **71** substantially cylindrical in shape and to slide the inside die **71** in the circumferential direction so that the inside pipes **72** and **73** and the outside pipes **64** are connected.

Alternatively, as shown in FIG. **11**, the inside die **71** need not be provided with the second inside pipes **73** and second header **75** and may be provided with only the first inside pipes **72** and first header **74**. In this case, the first header **74**, in the same way as the header **40** of the first embodiment, may be connected to both the coolant feed source **11** and gas feed source **12**. When configuring the inside die **71** in this way, the feed of coolant is started by using the drive mechanism **80** to slide the inside die **71** with respect to the outside die **61**, but the feed of gas is started by controlling the operation of the valves **47** and **48**.

Note that, in the above embodiments, the bottom die **60** was configured by an outside die **61** and an inside die **71**, but the top die **21** may be configured by an outside die and inside die. Alternatively, both the bottom die **60** and the top die **21** may be configured by outside dies and inside dies. Further, the die comprised of the outside die and inside die may be used for either the projecting die and recessed die which are used for press forming or may be used for both of the projecting die and recessed die.

Further, in the above embodiments, the inside die **71** was provided with only a single header for each kind of fluid, but it is also possible to provide a plurality of headers for each kind of fluid. In this case, for example, taking a coolant as an example, when stopping the feed of coolant to one part of the headers, it is possible to stop the feed of coolant from the first inside pipes **72** and outside pipes **64** which are connected to the first headers **74** to which feed has been stopped, and continue the feed of coolant from the remaining first inside pipes **72** and outside pipes **64**. That is, it is possible to selectively stop the feed of coolant. Due to this, it is possible to control the portions of the steel sheet K which are fed with coolant and change the hardness in the plane of the steel sheet K.

Further, in the above embodiments, the hot press forming operation of the steel sheet K as explained, but the invention can also be used for hot press forming a metal sheet other than steel sheet.

Note that, the present invention was explained in detail based on specific embodiments, but a person skilled in the art can make various changes, corrections, etc. without departing from the claims and concept of the present invention.

INDUSTRIAL APPLICABILITY

The present invention is useful when hot press forming steel sheet.

REFERENCE SIGNS LIST

1 hot press forming apparatus
10 hot press forming die
11 coolant feed source
12 gas feed source
13 control unit
20 bottom die
20*a* forming surface
21 top die
22 base
23 lift mechanism
30 positioning pin
40 header
41 pipe
42 projection
60 bottom die
61 outside die
63 sliding surface
64 outside pipe
71 inside die
72 first inside pipe
73 second inside pipe
74 first header
75 second header
K steel sheet
P prepierced hole

The invention claimed is:

1. A hot press forming method which shapes a heated metal sheet using a forming die which is comprised of a first die and a second die, comprising steps of:

arranging the heated metal sheet between said first die and said second die;

making said first die and said second die approach to press the metal sheet which is clamped between the two dies;

after pressing said metal sheet, feeding liquid state or mist state coolant to the surface of the metal sheet which is clamped between the two dies through a plurality of feed holes which are provided at least at one of said first die and said second die; and,

after said coolant finishes being fed, blowing a gas through said plurality of feed holes to the surface of the metal sheet,

wherein said first die and second die are separated before feeding said gas to the surface of the metal sheet.

2. The hot press forming method as set forth in claim **1** wherein a fluid switch for switching said coolant and said gas which are fed to said plurality of feed holes is provided inside at least one of said first die and second die.

3. The hot press forming method as set forth in claim **2** wherein

at least one of said first die and said second die has an outside die at which said feed holes are provided and an inside die which is arranged slidably inside said outside die;

said outside die is provided inside it with outside pipes which are arranged between a sliding surface between the outside die and said inside die, and said feed holes;

said inside die is provided inside it with first inside pipes which are arranged between said sliding surface and a connecting part which is connected to a coolant feed source and with second inside pipes which are arranged between said sliding surface and a connecting part which is connected to a gas feed source; and

said fluid switch makes said outside die and said inside die slide relative to each other to connect said outside pipes with the first inside pipes or second inside pipes and thereby switch between said coolant and said gas which is fed to said plurality of feed holes.

4. The hot press forming method as set forth in claim **2** wherein said coolant is either water or anti-rust oil.

5. The hot press forming method as set forth in claim **3** wherein said coolant is either water or anti-rust oil.

6. The hot press forming method as set forth in claim **1** wherein said coolant is either water or anti-rust oil.

7. A hot press forming die which presses and cools a heated metal sheet, comprising:

an outside die provided with feed holes which feed fluid to said metal sheet; and an inside die which is arranged slidably inside said outside die,

wherein said outside die is provided inside it with outside pipes which are arranged between a sliding surface between the outside die and said inside die and said feed holes;

said inside die is provided inside it with first inside pipes which are arranged between said sliding surface and a connecting part which is connected to a coolant feed source and with second inside pipes which are arranged between said sliding surface and a connecting part which is connected to a gas feed source; and

said outside pipes, first inside pipes, and second inside pipes are formed so that said outside pipes can be switched between at least a state connected to the first inside pipes and a state connected to the second inside pipes by making said outside die and said inside die move relative to each other.

8. The hot press forming die as set forth in claim **7** wherein said outside pipes, first inside pipes, and second inside pipes are formed so that said outside pipes can be switched between a state connected to the first inside pipes, a state connected to the second inside pipes, and a state not connected to the two inside pipes, by making said outside die and said inside die move relative to each other.

9. The hot press forming die as set forth in claim **8** wherein the pipeline lengths of the outside pipes are equal.

10. The hot press forming die as set forth in claim **8** wherein the die which is comprised of said inside die and said outside die is used as at least one of a top die and bottom die for press forming.

11. The hot press forming die as set forth in claim **7** wherein the pipeline lengths of the outside pipes are equal.

12. The hot press forming die as set forth in claim **11** wherein the die which is comprised of said inside die and said outside die is used as at least one of a top die and bottom die for press forming.

13. The hot press forming die as set forth in claim **7** wherein the die which is comprised of said inside die and said outside die is used as at least one of a top die and bottom die for press forming.

14. The hot press forming die as set forth in claim **7** wherein said coolant is any of water, an anti-rust oil, and mists of the same.

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